Field Report for Airborne Data Collected In Support of US EPA Region 6 Intercontinental Terminals Company LLC Fire 1 April 2019

Background

On 17 March 2019 a large fire was reported at the Intercontinental Terminals Company LLC (ITC) located in Deer Park, TX. Local reports indicate that the fire started at about 1030 local in an 80,000 barrel (capacity) tank storing naphtha. The ITC facility is located on the southern shore of the Houston ship channel in the City of Deer Park, TX. The geographical coordinates of the facility are 19.7322N, 95.1236W (figure 1).

The material reported in the fire is Naphtha. Naphtha is generally composed of either the first or second sequence of distillate obtained during primary distillation. Light naphtha is composed of light fraction straight chain and simple aromatics, typically less than 6 carbons while heavy naphtha consist of larger compounds (C6 plus) which normally is used as feed for catalytic cracking. Since the fraction of Naphtha is crude dependent, there is not a simple formula for the material.

The US EPA Region 6 requested that the ASPECT system be deployed to provide monitoring support on 17 March 2019 and ASPECT completed a 7 pass mission at 1847 local. Acetone was detected on the first 2 passes (data collection 3 and 4) which were near the fire at a concentration estimated below 1 ppm (0.154 ppm and 0.357 ppm, respectively). No other compounds were detected.

ASPECT conducted a second flight over the facility on 18 March 2019. Analysis of IR data confirmed reports that the fire had expanded to multiple tanks. Specifically, the thermal signature of the fire and resulting heated air plume was measurably larger than that observed in the first flight. Crew reports indicated that the plume rise was still active with the lofted plume occupying a region between 2000 and 6500 feet above ground with movement to the west. Spectral analysis of FTIR data indicated that compounds including 1-butene, 2-butene, isoprene, and acetone were detected primarily in a downwind portion of the plume with the highest values being just above 1 ppm.

ASPECT conducted a third flight over the ITC fire on 19 March 2019. Analysis of data indicated that the fire had grown as evident by the larger thermal signature and direct confirmation from aerial images. Plume geometry was assessed with the aircraft with findings showing the plume was about 47 miles in length, 17 miles wide at the largest extent and ranged in altitude from a floor of 1500 feet to a ceiling of 5000 feet. No chemical detections were reported on this flight.

ASPECT conducted a fourth flight over the ITC fire on 20 March 2019. Analysis of data indicated that the fire had been extinguished. Analysis of FTIR data showed detections of acetone and SO_2 to west of the farm and isobutylene and isoprene south of the farm. All concentrations were detected below 1 ppm.

Due to reports of vapors observed in the Deer Park vicinity ASPECT was requested to fly a fifth mission on 21 March 2019 near the impacted tank farm, and locations in Deer Park, La Porte, Galena Park and Jacinto City. Analysis of data showed normal temperatures within the farm and low levels of typical compounds within the urban atmosphere. Detected compounds included acetone and isobutylene at concentrations at or below 1 ppm.

ASPECT conducted a series of flight on 22 March 2019 with the focus being a possible breach of the tank farm secondary containment structure, discharge of foam and other material from the tank farm migrating into the ship channel and investigation of a re-ignition of a fire in the tank farm. IR results clearly showed the presence of material migrating into the ship channel and the presence of hot spots within the tank farm (corresponding to the fire). Detected compounds included acetone, 1, 3-butadiene, 1-butene, isobutylene and isoprene. Compounds detected in the general vacuity had concentrations less than 0.5 ppm while detections north of the tank farm during the fire showed levels less than 2 ppm.

ASPECT was dispatched on 23 March 2019 to fly a general data collection mission over the tank farm, at the confluence boom area on the ship channel and in a residential area northwest of the general area. Data continued to show that tanks in the NW corner were warmer than others in the tank farm with estimated temperatures being in the 30^{o}C to 40^{o}C range. IR images collected over the confluence into the ship channel showed boomed oil products with some leakage occurring. No chemical detections were observed on the flight.

ASPECT conducted a short flight on 24 March 2019 but was forced to return to base due to weather. Note that this aborted mission was flight 11. ASPECT conducted flight 12 on 25 March 2019 with the goal to conduct a general survey at the tank farm and downwind of the site. Imagery continued to show that tanks in the NW corner were warmer than others in the tank farm. IR images collected over the confluence into the ship channel continued to show boomed oil products with some leakage occurring with sheen being driven to the southwest due to winds. No significant chemical detections were observed on this flight.

ASPECT conducted flight 12 on 26 March 2019 with the goal to conduct a general survey at the tank farm and downwind of the site. Imagery collected on this flight indicated that the NW tanks in the tank farm were cooler than on previous flights. IR data collected over the confluence into the ship channel continued to show sheen in the waterway. No significant chemical detections were observed on this flight.

ASPECT conducted a flight 14 on 27 March 2019 with the goal to conduct a general survey at the tank farm and downwind of the site. Imagery collected on this flight indicated that the NW tanks in the tank farm were essentially at ambient temperature. Analysis of FTIR data showed one cluster of isobutylene north of the site at maximum levels of 1.60 ppm. IR and photographic data collected over the confluence area showed a reduction in the amount of trapped product. Leakage was still present but in less amounts as on prior flights.

ASPECT conducted flight 15 on 28 March 2019 with the goal to conduct a general survey at the tank farm and downwind of the site. The flight was impacted by isolated low level clouds. Imagery collected on this flight indicated that the NW tanks in the tank farm were at ambient temperature. IR and photographic data collected over the confluence area indicated that product was captured by the upstream boom and no significant boom leakage was present.

ASPECT conducted flight 16 on 31 March 2019. Imagery collected over the tank farms showed that six of the tanks in the farm are in the process of being removed. All structures were found to be at ambient temperature. IR and photographic data collected over the confluence area indicated that product continues to be present in the boom network with some leakage observed pushed against the ship channel boom. No compound detections were observed on this mission.

ASPECT was requested to fly the tank farm, confluence and downwind areas on the morning of 1April 2019. This report summarizes the findings of the mission.

Figure 1: ITC, Deer Park, TX

ASPECT response to this Mission/Incident was in support of:

US EPA Region 6. OSC: Adam Adams

ASPECT System

The US EPA ASPECT system collects airborne infrared (IR) images and chemical screening data from a safe distance over the site (about 3,000 ft AGL). The system consists of an airborne high speed Fourier transform infrared spectrometer (FTIR) coupled with a wide-area IR line scanner (IRLS). The ASPECT IR systems have the ability to detect compounds in both the 8 to 12 micron (800 to 1200 cm-1) and 3 to 5 micron (2000 to 3200 cm-1) regions. The 8 to 12 micron region is typically known as the atmospheric window region since the band is reasonably void of water and carbon dioxide influence. Spectrally, this region is used to detect carbon - non-carbon bonded compounds. The 3 to 5 micron region is also free of water and carbon dioxide but typically does not have sufficient energy for use. This band does show use in high-energy environments such as fires. The carbon - hydrogen stretch is very common in this region.

A digital Nikon DX2 camera (12.4 mega pixel CMOS 3:5 aspect ratio, 28 mm wide-angle lens) collects visible aerial imagery as part of the core data product package. The camera timing system is connected to the primary IR sensors and provides concurrent image collection when other sensors are triggered. All imagery is geo-rectified using both aircraft attitude correction (pitch, yaw, and roll) and GPS positional information. Imagery can be processed while in flight or approximately 600 frames per hour can be processed once the data are downloaded from the aircraft.

An Imperx mapping camera (29 mega pixels; mapping focal plane array) provides a similar aspect ratio and aerial coverage. Like the Nikon DX2, it is connected to the primary IR sensors and provides concurrent image collection when other sensors are triggered. These images are often digitally processed in lower resolution so they can be transmitted via satellite communication. The high resolution images (>20 MB each) are pulled from the ASPECT after the sortie and are available at a later time.

All aerial photographic images collected by the ASPECT system are ortho-rectified and geospatially validated by the reachback team. In general, this consists of conducting geo-registration using a Digital Elevation Model (DEM) which promotes superior pixel computation and lessens topographic distortion. The image is then check by a team member (using a Google Earth base map) for proper location and rotation

Data is processed using automated algorithms onboard the aircraft with preliminary results being sent using a satellite system to the ASPECT reachback team for QA/QC analysis. Upon landing preliminary data results are examined and validated by the reachback team.

Data Results Flight 17, 1 April 2019

Weather Conditions and Crew Report

Weather for the mission is given in table 1. The crew reported that winds at flight level (2800 ft) were from 100 degrees at 14 kts (7 m/s). Minimal turbulence was encountered some ground obscuration due to clouds. No significant ground activity was observed on flight 17.

Table 1. ITC Fire Mission Weather 1 April 2019

Parameter	Surface (1000)
Wind direction	335 degrees
Wind speed	2.7 m/s
Temperature	11^{o}C
Humidity	52%
Dew Point	3.3^{o}C
Pressure	1018 mb
Ceiling	Not Reported

The order to launch the aircraft was given at 0800 local on 1 April 2019 with a time over target set for 0930. The aircraft was airborne at 0924 with the initial data collection run over the site was at 0935 (local) and the aircraft made a total of 6 data collection passes. Flight information is summarized in Appendix A and Figure 2.

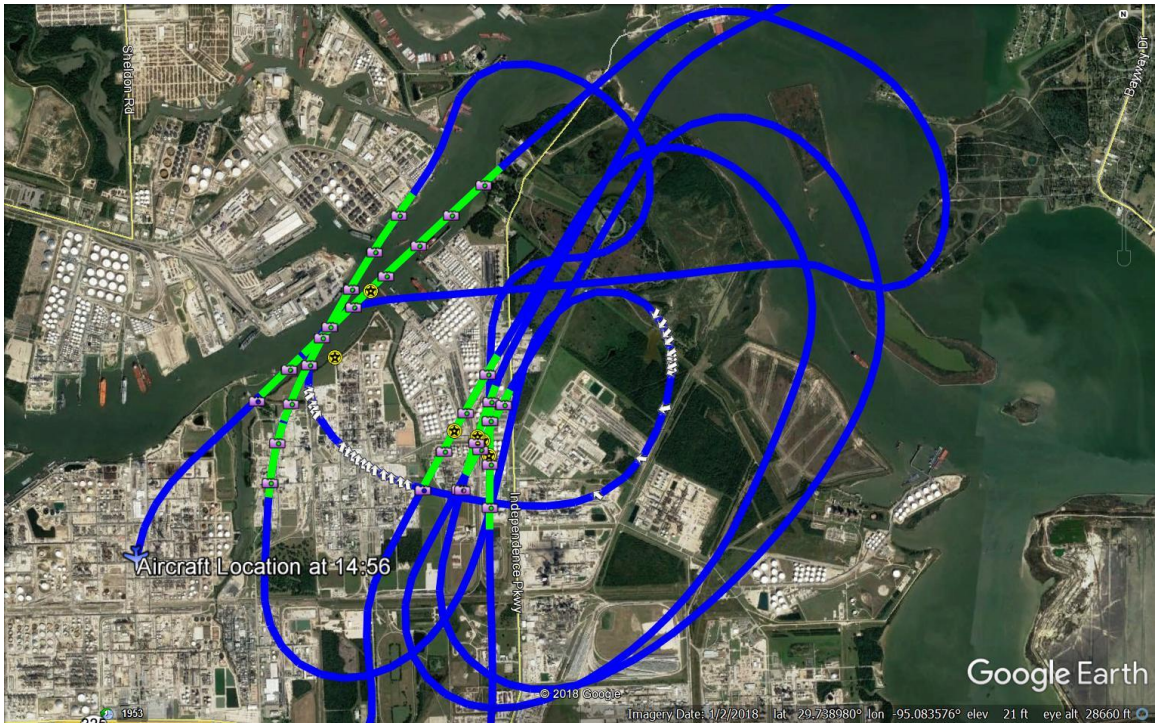

Figure 2: Flight line data for 1 April 2019, Flight 17. The blue lines represent the ASPECT flight path, green lines represent when the Infrared Line Scanner was actively collecting data, and the camera icons represent when a photo was taken.

General Data Quality Objective

The following general data quality objectives are employed in conducting emergency response data collection with ASPECT:

1. To support overall situational analysis of the incident including aerial photography and IR imagery
2. To screen the incident for the presence of selected chemicals
3. To estimate the location and concentration of plumes being generated by the incident.

Line Scanner Data Results

A total of 1 test and 6 data passes were made in the proximity of the impacted tank farm and also in extended areas surrounding the site and infrared line scanner images were generated for each pass. Figure 3 shows a typical 3-band infrared image obtained from data collected for Run 3. IR imagery of the tank farm indicates that all tanks are at ambient temperature other than IR solar heating. As with the flight on 31 March 2019 with tanks in the NE corner of the farm are the coolest.

An IR image of the confluence area is given in Figure 4. Boomed oil can be seen against the booms and light sheen is present in the main channel. There appears to be sheen leaking from the southern section of booms on the ship channel.

Figure 3: IR image of ITC data for 1 April 2019, Flight 17 Run 5

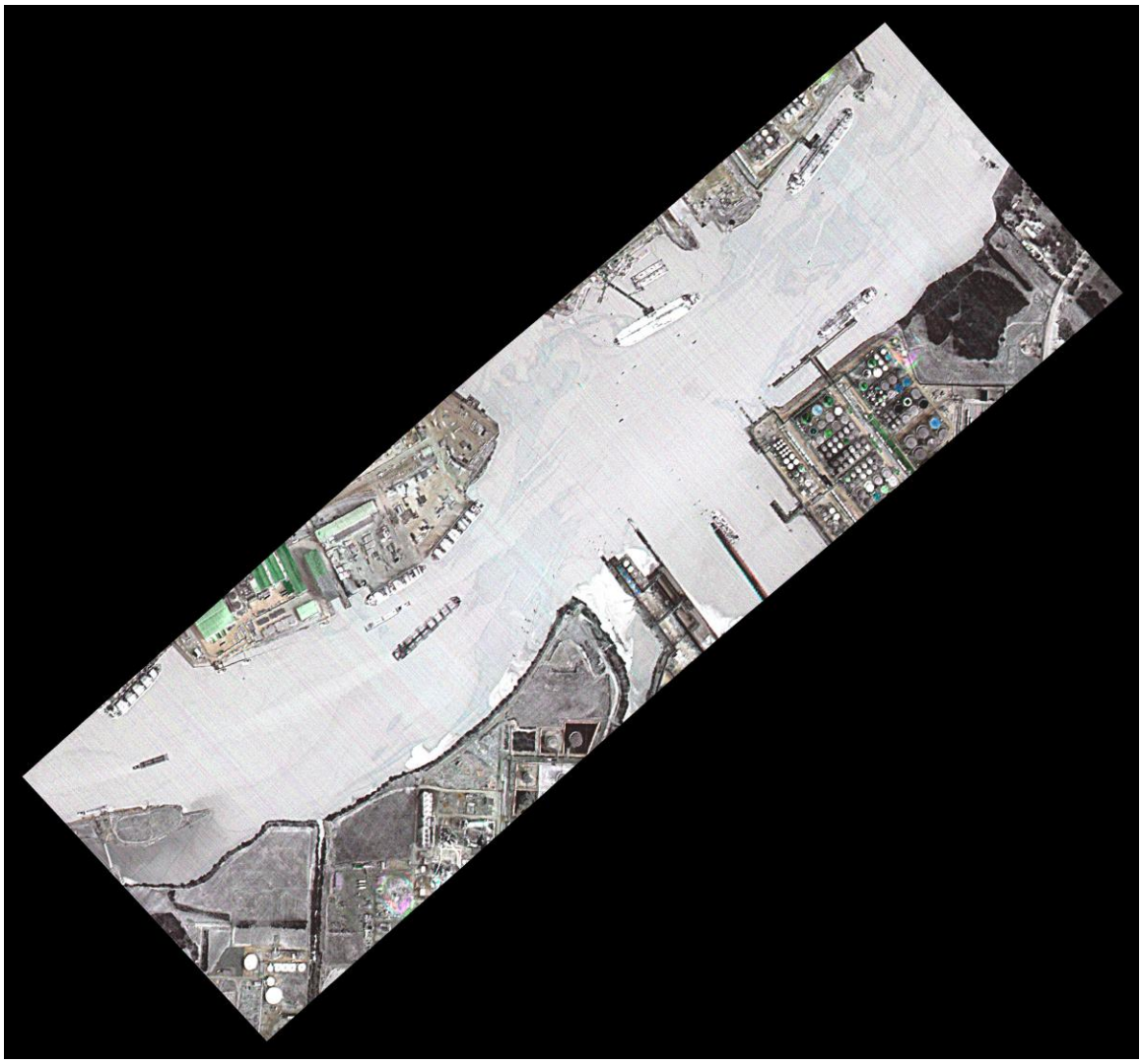

Figure 4: IR Image of Contained Oil 1 April 2019, Fight 17, Run 7

FTIR Data Results

FTIR Spectral data at a resolution of 16 wavenumbers was collected for each pass. ASPECT uses an automated detection algorithm to permit compounds to be analyzed while the aircraft is in flight. 72 compounds are included in this algorithm and the list and associated detection limits are given in Tables 2. In addition, collected data are also manually analyzed by comparing any detected spectral signatures to a collection of published library spectra.

No detections were observed on this flight. Details of the data collection are given in Table 3.

TABLE 2 - Chemicals Included in the ASPECT Auto-Processing Library

Acetic Acid	Cumene	Isoprene	Propylene
Acetone	Diborane	Isopropanol	Propylene Oxide
Acrolein	1,1-Dichloroethene	Isopropyl Acetate	Silicon Tetrafluoride
Acrylonitrile	Dichloromethane	MAPP	Sulfur Dioxide
Acrylic Acid	Dichlorodifluoromethane	Methyl Acetate	Sulfur Hexafluoride
Allyl Alcohol	Difluoroethane	Methyl Ethyl Ketone	Sulfur Mustard
Ammonia	Difluoromethane	Methanol	Nitrogen Mustard
Arsine	Ethanol	Methylbromide	Phosgene
Bis-Chloroethyl Ether	Ethyl Acetate	Methylene Chloride	Phosphine
Boron Tribromide	Ethyl Formate	Methyl Methacrylate	Tetrachloroethylene
Boron Triflouride	Ethylene	MTEB	1,1,1-Trichloroethane
1,3-Butadiene	Formic Acid	Naphthalene	Trichloroethylene
1-Butene	Freon 134a	n-Butyl Acetate	Trichloromethane
2-Butene	GA (Tabun)	n-Butyl Alcohol	Triethylamine
Carbon Tetrachloride	GB (Sarin)	Nitric Acid	Triethylphosphate
Carbonyl Chloride	Germane	Nitrogen Trifluoride	Trimethylamine
Carbon Tetraflouride	Hexafluoroacetone	Phosphorus Oxychloride	Trimethyl Phosphite
Chlorodifluoromethane	Isobutylene	Propyl Acetate	Vinyl Acetate

Table 3. Chemical Results Summary, Flight 17

Run	Date	Time (UTC)	Chemical	Max Concentration ppm
1	1 April 2019	0932	Test	Test
2		0935	ND	None
3		0939	ND	None
4		0942	ND	None
5		0945	ND	None
6		0947	ND	None
7		0955	ND	None
ND – Non-detect				

Aerial Photography Results

A full set of high resolution aerial digital photography was collected as part of the flight. Figure 5 shows a representative overhead image collected as part of each pass over the tank farm. Analysis of the image shows that several of the tanks appear to have the tops removed or collapsed. An oblique image of the tank farm confirms the status of the area (figure 6).

An aerial image of the confluence area is shown in Figure 7. Numerous booms continue to be used to secure the release with produce still present in the upper booms. The image shows the presence of sheen throughout the main channel. An oblique of the same area

confirms the findings in the aerial view with sheen present in the lower booms and main channel (figure 8).

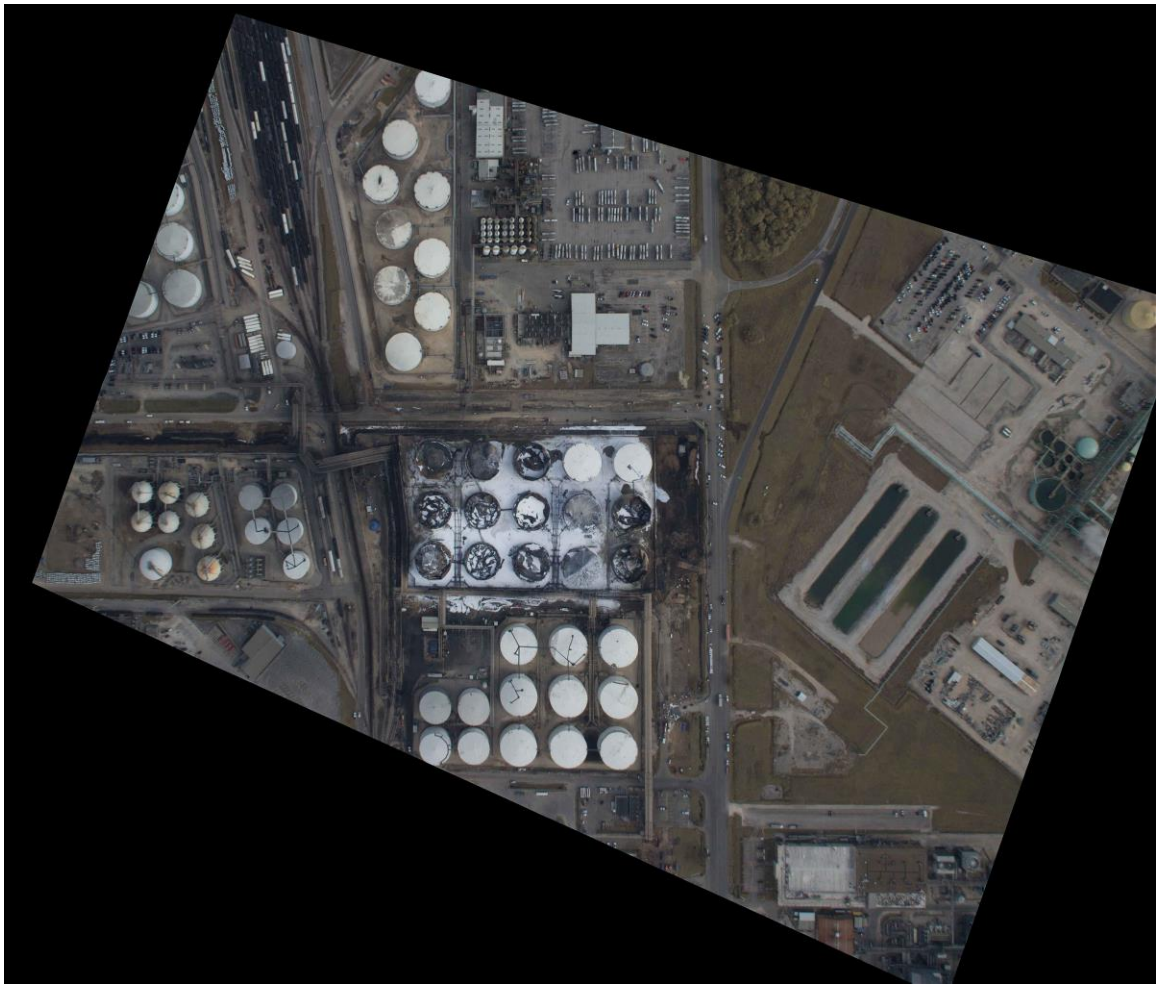

Figure 5: Aerial Image of the Tank Farm, 1 April 2019, Flight 17

Figure 6: Oblique Image of the Tank Farm, 1 April 2019 Flight 17

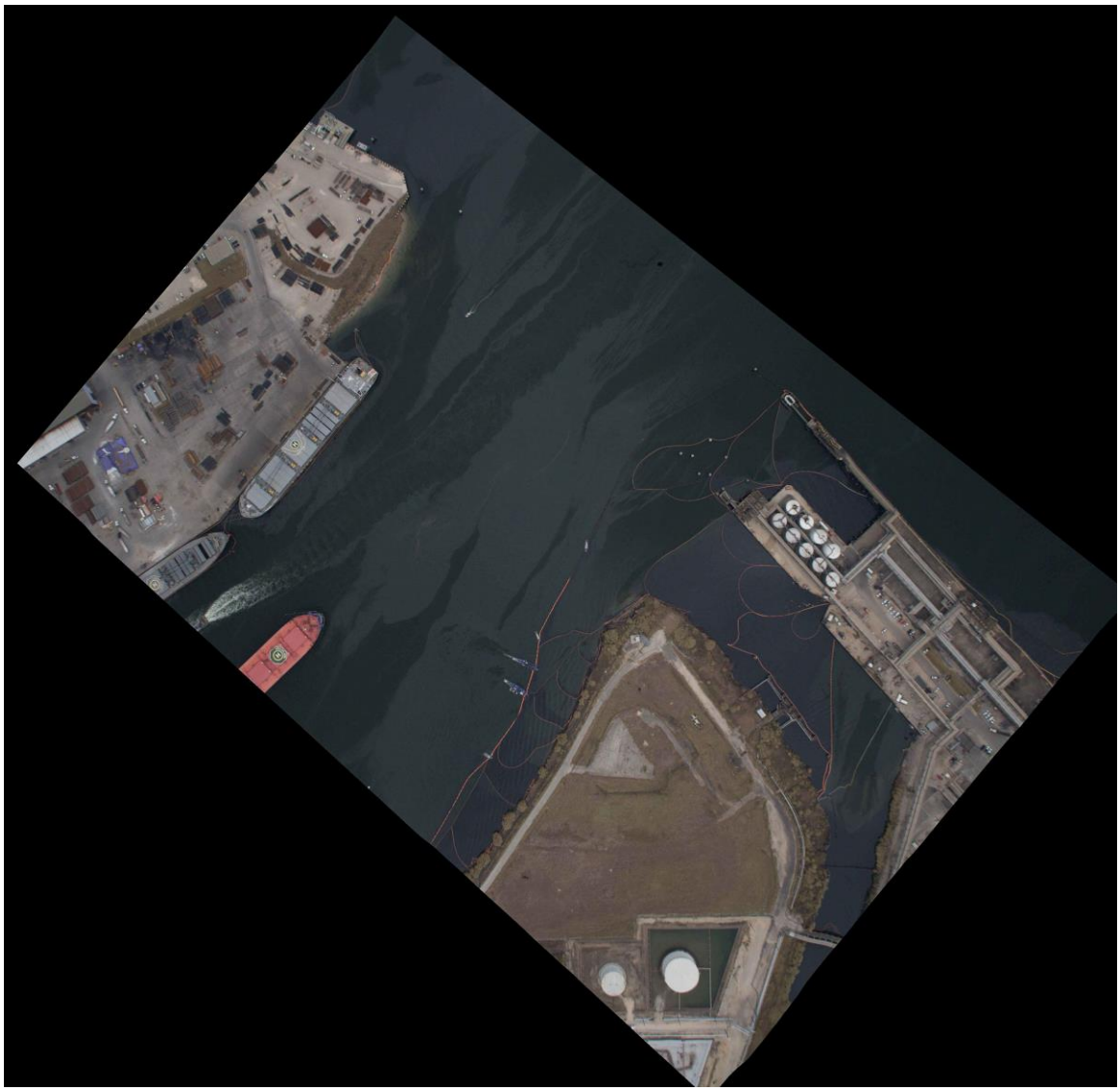

Figure 7: Aerial Image of the Ship Channel Boom Area, 1 April 2019, Flight 17

Figure 8: Oblique Image of the Ship Channel Boom Area, 1 April 2019, Flight 17

Conclusions

ASPECT conducted flight 17 on 1 April 2019 with the goal to conduct a general survey at the tank farm and downwind of the site. Imagery collected over the tank farms showed a similar state as on the prior flight, namely that six of the tanks in the farm are in the process of being removed or collapsed. IR and photographic data collected over the confluence area indicated that product continues to be present in the boom network with some leakage. No compound detections were observed on this mission.

Appendix A

Abbreviations:

DEM – Digital elevation model
Alt – Altitude (in feet)
MSL – Mean sea level altitude (in feet)
Digital – Digital photography file from the Nikon D2X camera
MSIC – Digital photography file from the Imperx mapping camera
FTIR – Spectral IR data collected with a Fourier Transform Infrared Spectrometer
IRLS – Infrared Line Scanner
Jpg – JPEG image format
UTC – Universal Time Coordinated
img – Spectral data format based on Grams format

```
Mission:   2019-04-01 ITC Fire

Date:      4/1/2019
Time UTC: 14:24

Aircraft Number: N9738B
Pilot: Todd Seale
Copilot: Beorn Ledger
Operator: James Crisp
Aft Operator: Gerry Broyles
Ground Controller: Tim Curry

DEM: Using elevation from DEM Database
---------------------------------------------------------------------

Run: 1 Time: 14:32:24 UTC
        Alt: 2842 ft MSL  Elev: 20 ft  Elevation from DEM Database
        Vel: 110 knots  Heading: 255

Digitals:  None
MSIC: 3
        20190401143230088.jpg
        20190401143236437.jpg
        20190401143242802.jpg
FTIR: 1
        20190401_143228_A.igm
IRLS: 1
        2019_04_01_14_32_28_R_01 TA=1.0;TB=21.0;Gain=3
Gamma Runs:  None

---------------------------------------------------------------------
```

Run: 2 Time: 14:35:12 UTC
        Alt: 2711 ft MSL Elev: 20 ft Elevation from DEM Database
        Vel: 115 knots Heading: 193

Digitals: None
MSIC: 3
        20190401143518053.jpg
        20190401143524402.jpg
        20190401143531672.jpg
FTIR: 1
        20190401_143516_A.igm
IRLS: 1
        2019_04_01_14_35_17_R_02 TA=3.5;TB=23.3;Gain=3
Gamma Runs: None

Run: 3 Time: 14:39:08 UTC
        Alt: 2800 ft MSL Elev: 19 ft Elevation from DEM Database
        Vel: 118 knots Heading: 201

Digitals: None
MSIC: 3
        20190401143914113.jpg
        20190401143921367.jpg
        20190401143927732.jpg
FTIR: 1
        20190401_143912_A.igm
IRLS: 1
        2019_04_01_14_39_13_R_03 TA=7.2;TB=27.3;Gain=3
Gamma Runs: None

Run: 4 Time: 14:42:44 UTC
        Alt: 2793 ft MSL Elev: 16 ft Elevation from DEM Database
        Vel: 117 knots Heading: 205

Digitals: None
MSIC: 4
        20190401144251094.jpg
        20190401144257459.jpg
        20190401144303808.jpg
        20190401144310157.jpg
FTIR: 1
        20190401_144248_A.igm
IRLS: 1
        2019_04_01_14_42_49_R_04 TA=7.0;TB=27.0;Gain=3
Gamma Runs: None

Run: 5 Time: 14:45:45 UTC
        Alt: 2846 ft MSL Elev: 18 ft Elevation from DEM Database

```
        Vel: 115 knots  Heading: 3

Digitals:  None
MSIC: 3
        20190401144550853.jpg
        20190401144557217.jpg
        20190401144603567.jpg
FTIR: 1
        20190401_144548_A.igm
IRLS: 1
        2019_04_01_14_45_49_R_05 TA=9.1;TB=29.0;Gain=3
Gamma Runs:  None

-------------------------------------------------------------------

Run: 6 Time: 14:47:47 UTC
        Alt: 2834 ft MSL  Elev: 5 ft  Elevation from DEM Database
        Vel: 112 knots  Heading: 200

Digitals:  None
MSIC: 8
        20190401144753422.jpg
        20190401144759787.jpg
        20190401144806136.jpg
        20190401144812501.jpg
        20190401144818850.jpg
        20190401144825199.jpg
        20190401144831564.jpg
        20190401144837913.jpg
FTIR: 2
        20190401_144750_A.igm
        20190401_144829_A.igm
IRLS: 1
        2019_04_01_14_47_51_R_06 TA=10.0;TB=30.1;Gain=3
Gamma Runs:  None

-------------------------------------------------------------------

Run: 7 Time: 14:55:33 UTC
        Alt: 2692 ft MSL  Elev: -3 ft  Elevation from DEM Database
        Vel: 119 knots  Heading: 221

Digitals:  None
MSIC: 8
        20190401145540091.jpg
        20190401145546440.jpg
        20190401145552805.jpg
        20190401145559154.jpg
        20190401145605519.jpg
        20190401145611868.jpg
        20190401145618218.jpg
        20190401145624582.jpg
FTIR: 2
        20190401_145537_A.igm
```

20190401_145616_A.igm
IRLS: 1
2019_04_01_14_55_38_R_07 TA=10.2;TB=30.2;Gain=3
Gamma Runs: None